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①⑨ (CA) **CANADIAN PATENT** ⑫

⑤④ MAINTAINING DILUENT/BITUMEN RATIO IN THE
HOT WATER PROCESS FOR BITUMEN RECOVERY

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ABSTRACT

The viscosity of a stream of bitumen froth diluted with a hydrocarbon diluent is continuously measured to obtain an indication of the relative viscosity of the hydrocarbon phase in the stream. These measurements are used to control the rate of addition of diluent to the undiluted froth so as to keep the diluent/bitumen ratio within the diluted froth at a desired value. Close control of the ratio in this manner reduces wastage of diluent and improves the operation of the downstream centrifugal separators.

This invention relates to a method for monitoring the diluent/bitumen ratio in diluted froth from the hot water process, whereby diluent addition to the undiluted froth can be controlled to ensure a substantially constant and desirable ratio.

One of the world's largest reservoirs of hydrocarbons is the Athabasca tar sand deposit in Northern Alberta. The oil or bitumen from this deposit is presently being extracted using the known hot water process.

In general terms, this process involves mixing tar sand with water and steam in a rotating tumbler to initially separate the bitumen from the water and solids of the tar sand and to produce a slurry. The slurry is diluted with additional water as it leaves the tumbler and is introduced into a cylindrical primary settler vessel having a conical bottom. The coarse portion of the solids settles out in this vessel and is removed as an underflow and discarded. Most of the bitumen and minor amounts of solids and water rise to the surface of the vessel contents to form a froth. This froth overflows the vessel wall and is received in a launder extending around its rim. The froth is termed primary froth. A middlings stream, comprising water, fine solids (-325 mesh), and a minor amount of buoyant and non-buoyant bitumen, is withdrawn from the mid-section of the vessel and is pumped to a sub-aeration flotation cell. Here the middlings are relatively violently agitated and aerated. The middlings bitumen becomes attached to the air bubbles and rises through the cell contents to form a froth. This froth, termed secondary froth, is recovered in a launder and settled to reduce its water and solids content. The primary froth and settled secondary froth are combined and preferably deaerated in a column with steam to provide the feed stock for this invention. Typically the feed stock froth comprises 62% bitumen, 29% water and 9% solids. The temperature of froth after deaeration is typically 185°F.



Following deaeration, the froth is pumped through a feed conduit to a two-stage centrifugal separation circuit. A hydrocarbon diluent is injected into the feed conduit to mix with the froth. The diluent, usually naphtha, is added to reduce the viscosity and specific gravity of the froth bitumen phase to render it amenable to centrifugal separation. In the first stage of the circuit, the diluted froth is treated in one of a battery of scroll-type separators. These separators remove most of the coarse solids from the froth. The product is then passed through one of a battery of disc-type separators to remove the remaining fine solids and the water and produce a relatively clean diluted bitumen stream.

The present invention arises from the lack of instrumentation, applicable in a practical sense, available for accurately and quickly determining the flow rate of bitumen through the feed conduit. Because the bitumen content of the froth cannot presently be easily determined, due to the presence of water and solids, it is difficult to ensure a substantially constant and desirable diluent/bitumen ratio in the diluted froth. More particularly, it is found that a low diluent/bitumen ratio tends to make operation of both sets of centrifuges difficult - that is, the machines require a good deal of operator attention in this circumstance. Further, a low diluent/bitumen ratio reduces the separation efficiency of the machines. Due to these problems, there is a tendency on the part of the operators to seek to err on the side of too high a diluent/bitumen ratio, thereby wasting diluent. In addition, a too high diluent/bitumen ratio reduces the efficiency of the centrifugal separators. There is therefore required an accurate and practical system for monitoring the ratio so that it can be accurately maintained at the desired level.

With the foregoing in mind, it is the object of this invention to provide a method whereby the diluent/bitumen ratio of the diluted froth is effectively monitored, so that the addition of diluent to undiluted froth may be controlled to ensure a substantially constant ratio.

5 Broadly stated, the invention is an improvement in the dilution centrifuging process wherein hydrocarbon diluent is added to bitumen froth before the diluted froth is treated in centrifugal separators. The improvement comprises pumping a sample of the diluted froth at a constant rate through a tubular loop of known dimensions to generate a pressure
10 drop across the loop which is proportional to the viscosity of the sample; and varying the rate of addition of the diluent to the froth in response to such pressure drop to maintain a substantially constant diluent/bitumen ratio in the diluted froth.

In the drawing:

15 Figure 1 is a schematic diagram illustrating the system; and Figure 2a is a plot of the hydrocarbon phase viscosity of diluted froth as a function of the naphtha-bitumen ratio;

Figure 2b is a plot of tubing viscometer readings taken on diluted froth as a function of naphtha-bitumen ratio.

20 With reference to Figure 1, deaerated bitumen is continuously delivered from an extraction plant or source 1 to a froth surge tank 2. The surge tank is preferably only partially filled and is of sufficient capacity so that the retention time therein is in the order of at least 1 hour, preferably 2 - 3 hours. A plurality of side entry mixers 3 extend
25 into the tank 2 for turning its contents over several times while the froth passes therethrough.

On leaving the surge tank 2, the froth is pumped through the feed conduit 4 by a variable speed feed pump 5.

Naphtha or like diluent is introduced into the

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froth feed conduit 4 before it reaches the scroll centrifuge battery 6. More particularly, naphtha is fed by a centrifugal pump 7 from a storage tank 8 through a conduit 9 into feed conduit 4.

5 The flow of naphtha through the conduit 9 is controlled by a valve 10 on the discharge of a naphtha heater. The rate of naphtha flow is measured by an orifice meter 12 ahead of the heater. The flow of combined naphtha and froth (i.e. diluted froth) through the feed conduit 4 is also
10 measured with an orifice meter 13 downstream of the froth-naphtha junction 20. The flow of naphtha is regulated as a pre-set ratio of the diluted froth flow by a flow ratio controller 14, connected to the meters 12, 13. The flow ratio controller 14 operates to control the valve 10. A viscometer 15 operates
15 to provide a viscosity controller 14a with a signal indicative of the viscosity of the diluted froth. The viscosity signal is utilized by the viscosity controller 14a to re-set the naphtha/froth ratio setpoint on the flow ratio controller 14 in order to maintain the diluted froth at a more or less constant
20 viscosity.

 The viscometer 15 comprises a positive displacement pump 16 which withdraws a sample at a constant rate from the diluted froth conduit 4 and pumps it through a conduit loop 17 and back into the conduit 4. A differential pressure cell
25 18 measures the pressure drop across the loop 17 and transmits the required proportional signal to the viscosity controller 14a. A suitable viscometer is obtained by using a 3L2 Moyno pump and a 25 foot long loop of 3/8 inch inside diameter tubing.

 It has been found that variations in the viscosity
30 of the diluted froth arise largely from variations in the bitumen content of the froth. So little variation in the froth viscosity arises from changes in the solids and water

contents thereof that they can be ignored. The froth viscosity measurement can therefore be used as an indicator of the relative viscosity of the hydrocarbon phase in the diluted froth.

5 The diluted froth conduit 4 terminates in a distributor vessel 19. This vessel 19 has upwardly inclined connector lines 20, each leading to a scroll centrifuge 21. A pressure sensor 22 monitors the pressure within the distributor vessel 19 and transmits a signal proportional thereto to a controller 23 which regulates the speed of the froth feed pump 10 5 to reduce pressure surges at the vessel 19.

The present system is characterized by several advantages. By providing a large froth surge tank and blending its contents, wide fluctuations in the froth composition and flow rate are evened out so that changes occur only gradually. 15 This improves the operation of the separator circuit. In addition, as a result of providing surge capacity, it is possible to use a fast-acting pressure response system to control the froth feed pump and minimize surge conditions at the scroll separators. By monitoring the viscosity of the 20 diluted froth, it is possible to maintain the diluent/bitumen ratio generally constant at a pre-determined value. This improves the efficiency of the separators and conserves diluent. Finally, by using a distributor vessel, emulsification of the diluted froth is reduced. Not all of these advantages need be 25 incorporated in a system. As stated, the broadest aspect of the invention is the concept of retaining and mixing the undiluted froth. However it is preferable to incorporate the other features of the invention as well.

30 Certain aspects of the invention are exemplified by the following data:

Example I

The usefulness of agitating froth to improve its

homogeneity can be illustrated by comparing the standard deviation of the water content (or solids content) of unagitated diluted froth with the standard deviation of the water content (or solids content) of agitated diluted froth. Typically, the mean of the water and solids contents of diluted froth from average tar sand as well as their standard deviations, both in the agitated and unagitated states are as follows.

UNAGITATED FROTH			AGITATED FROTH	
<u>Component</u>	<u>Mean</u>	<u>Std. Dev.</u>	<u>Mean</u>	<u>Std. Dev.</u>
Water	26.27%	5.46%	27.79%	3.37%
Solids	7.56%	5.72%	6.06%	0.93%

As shown in the tables above, the expected solids content of a random sample of unagitated diluted froth could vary from 1.84% to 13.28% while the expected solids contents of a random sample of agitated diluted froth could vary only from 5.13% to 6.99%.

Example II

The viscometer data shown in Figures 2a and 2b show that the tubing viscometer, when applied to bitumen froth, does, in fact, give readings indicative of the hydrocarbon phase viscosity. Figure 2a shows the hydrocarbon phase viscosity of naphtha-bitumen samples (which were taken during tubing viscometer tests) as a function of the naphtha/bitumen ratio. The data illustrated in Figure 2b shows the actual tubing viscometer readings as a function of naphtha/bitumen ratio. It will be noted that the curves are similar in shape. Comparison of the low water froth data with the high water froth data in Figure 2b shows that the viscosity readings (between high and low water froth) vary by a maximum of 10% while the water content of the froth varied from 27% to 47%. Figure 2b also illustrates that the tubing viscometer can be made more insensitive to the froth water content by providing the

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viscometer with a long residence time suction device (30 sec.)
thereby allowing some of the water to separate from the
hydrocarbon before the mixture enters the tubing downstream
of the pump. By "suction device" is meant an upwardly inclined
(45°) suction pipe extending from the centre of the froth line
to the centrifugal pump supplying the viscometer loop. A 2 1/2"
diameter suction pipe was used to provide a "long residence
time", thereby allowing some solids and water to settle out
of the sample and slide back to the froth line. A 1/4"
diameter suction pipe was used to provide a "short suction time".

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

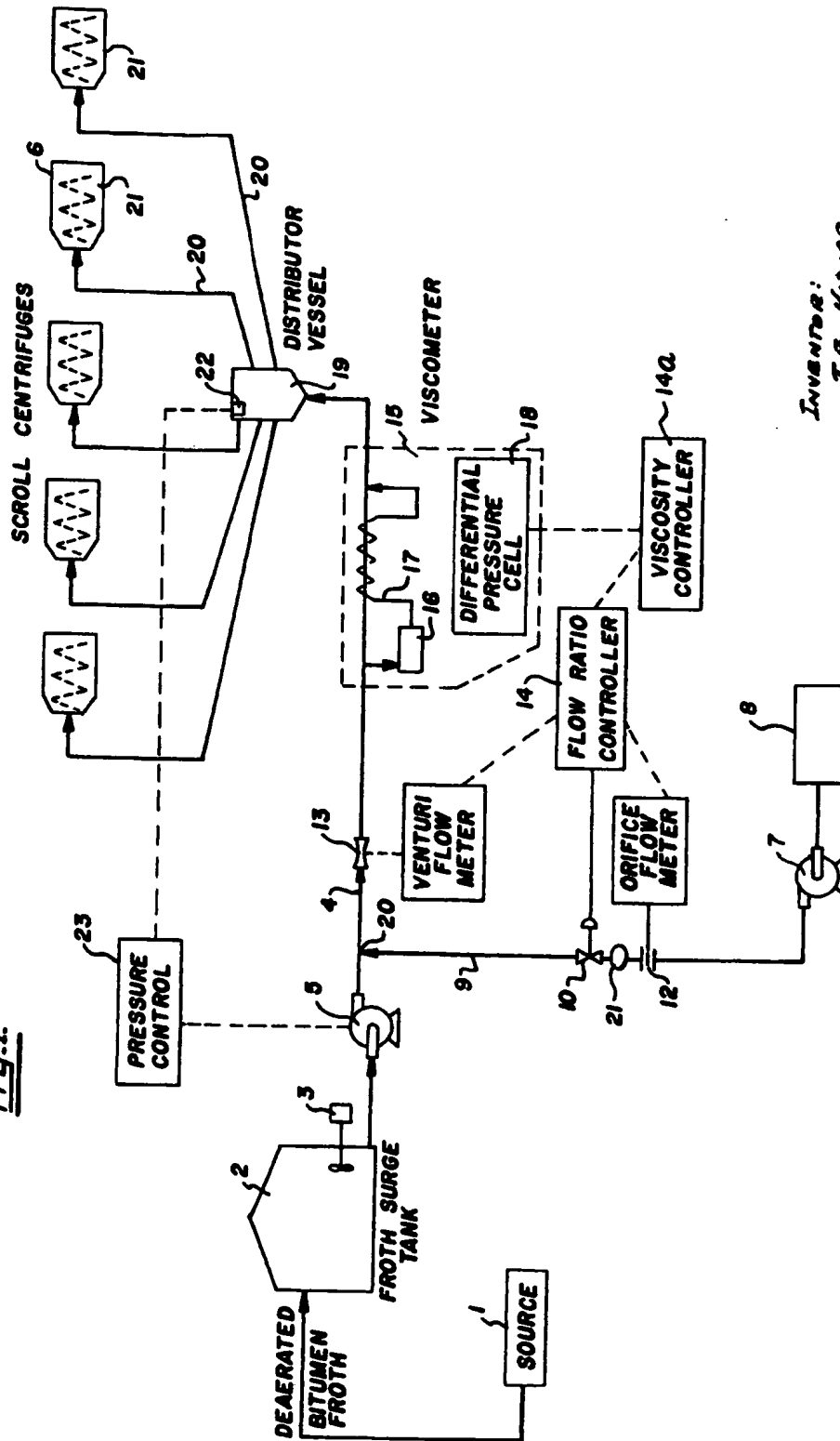
1. In a dilution centrifuging process wherein hydrocarbon
diluent is added to bitumen froth, containing varying amounts of bitumen,
5 water and solids, before the diluted froth is treated in centrifugal
separators, the improvement comprising:

measuring the viscosity of the diluted froth by pumping a sample
of the diluted froth at a substantially constant rate through a tubular
loop of known dimensions to generate a pressure drop across the loop which
10 is proportional to the viscosity of the sample; and

varying the rate of addition of the diluent to the froth in
response to such pressure drop to maintain a substantially constant diluent/
bitumen ratio in the diluted froth.



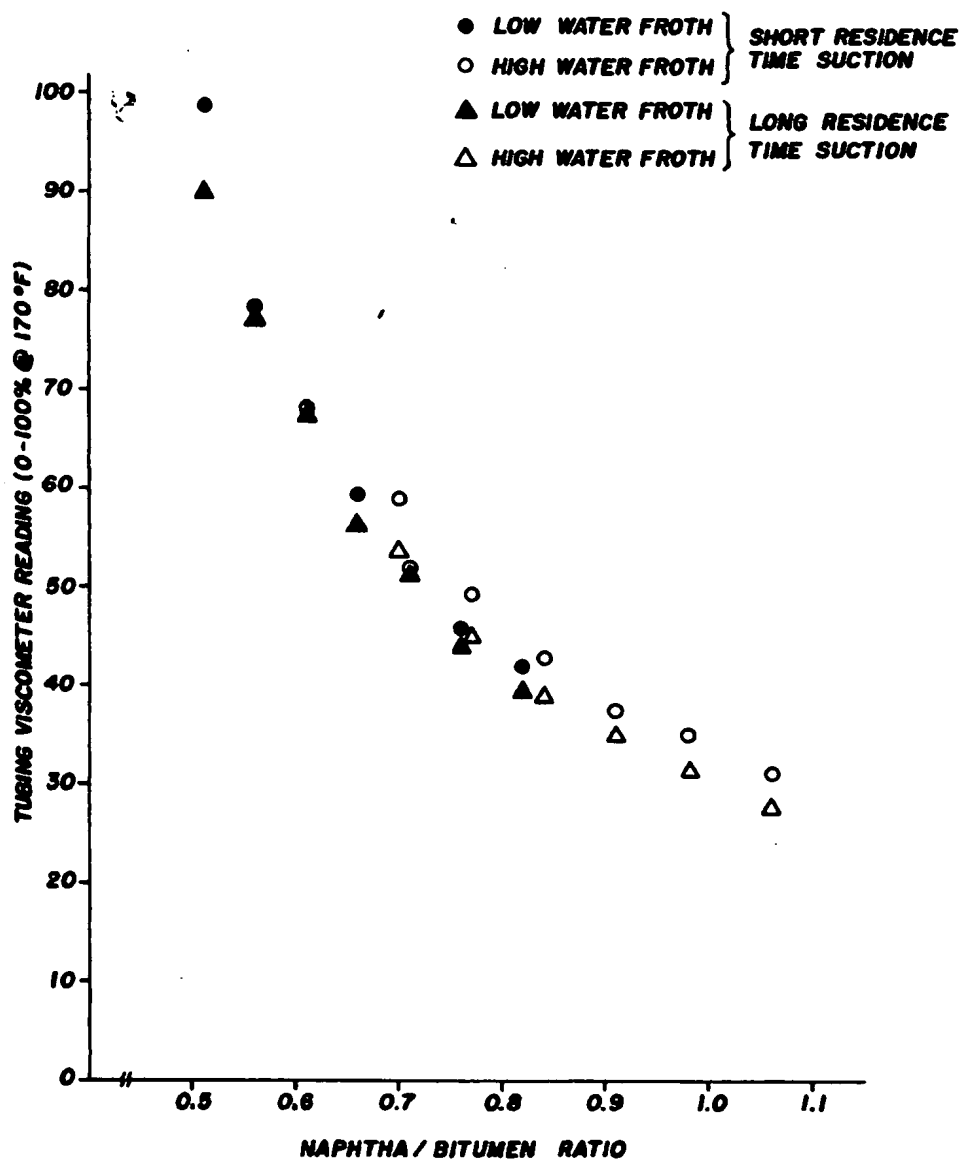
Fig. 1



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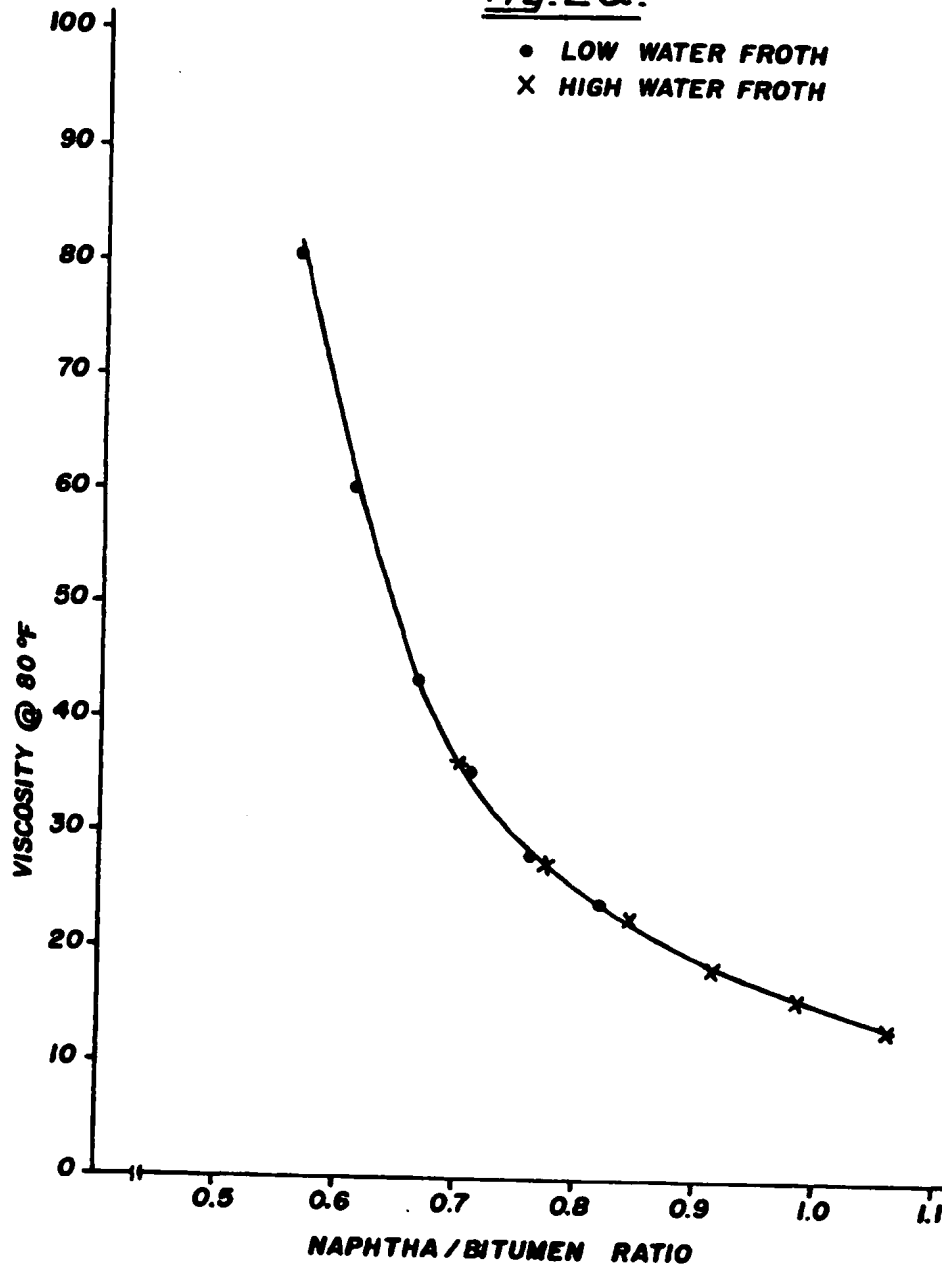
Fig. 2b.



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Fig. 2a.



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